Det CO2 neutrale amartur - CopenHybrid

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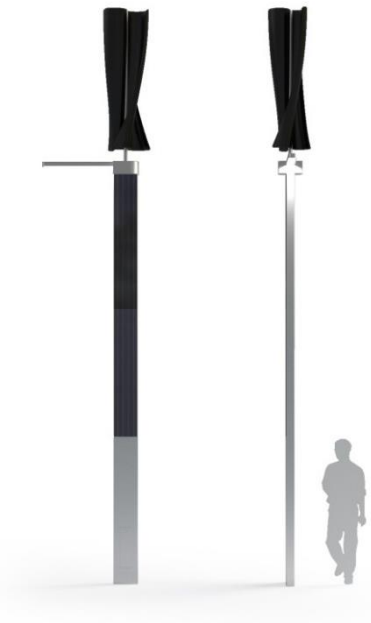
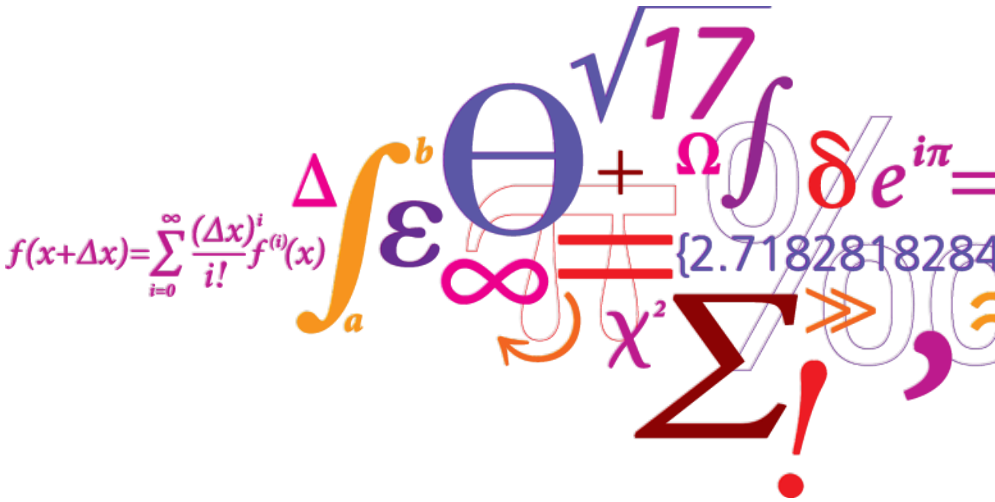
CO_2 neutralt armatur – CopenHybrid

Peter Poulsen – Projektleder - DTU Fotonik RISØ Campus

ELFORSK Projektnr. 343-021

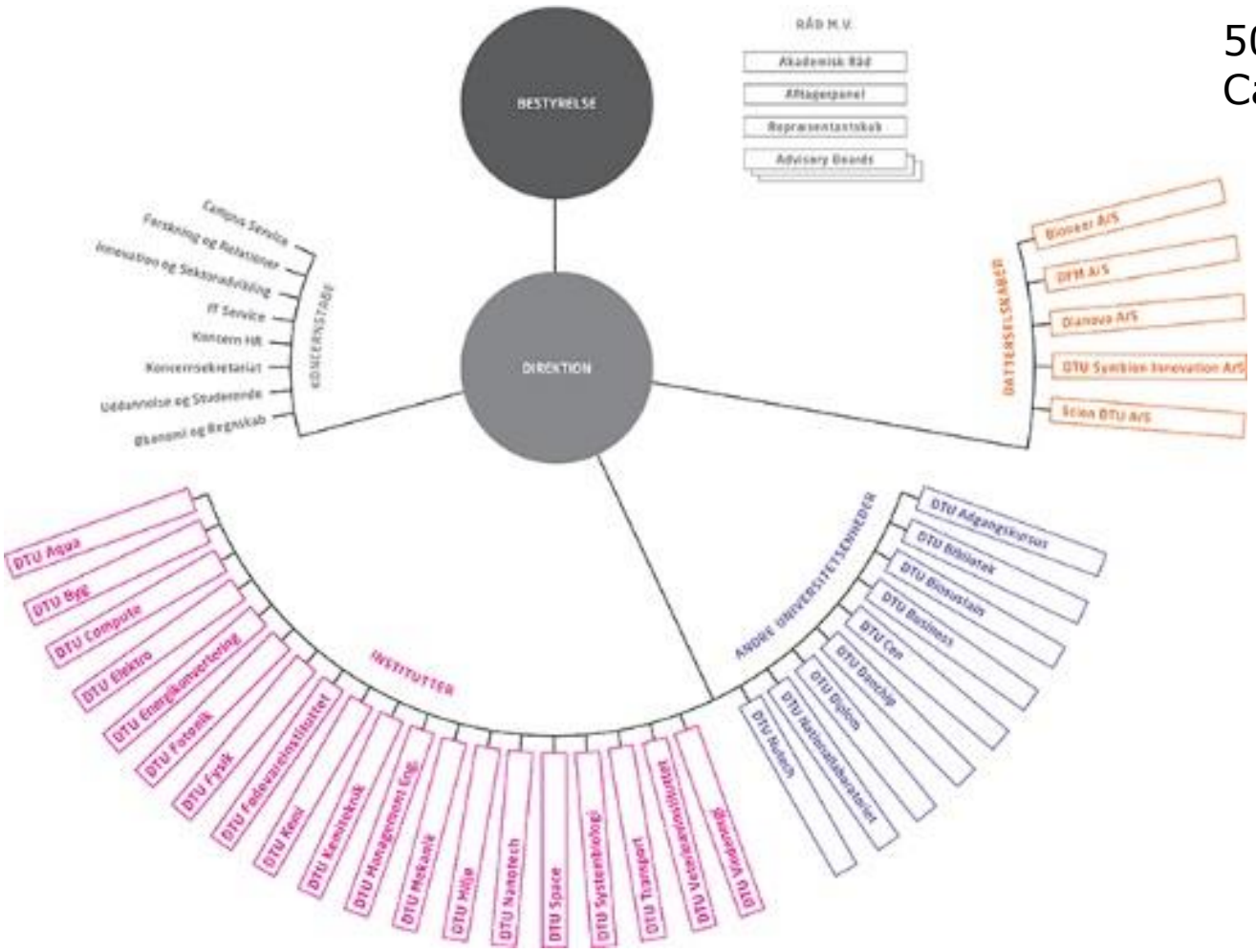




6. november 2013

Danmark Tekniske Universitet

5000 ansatte
Ca. 7.500 studerende



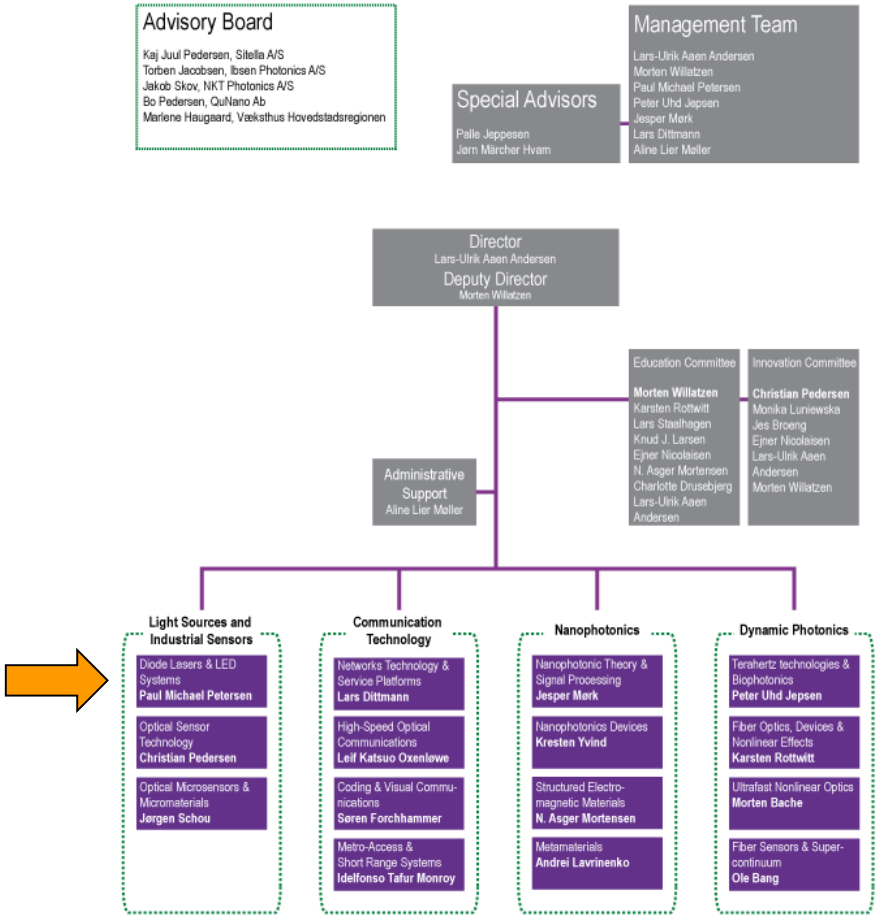
6. november 2013

DTU Fotonik - organisering

>200 Ansatte
>50 ph.d. studerende
Arbejder med alle aspekter af lys

Diode Laser & LED Systems

- The Laser Team
- The LED Team



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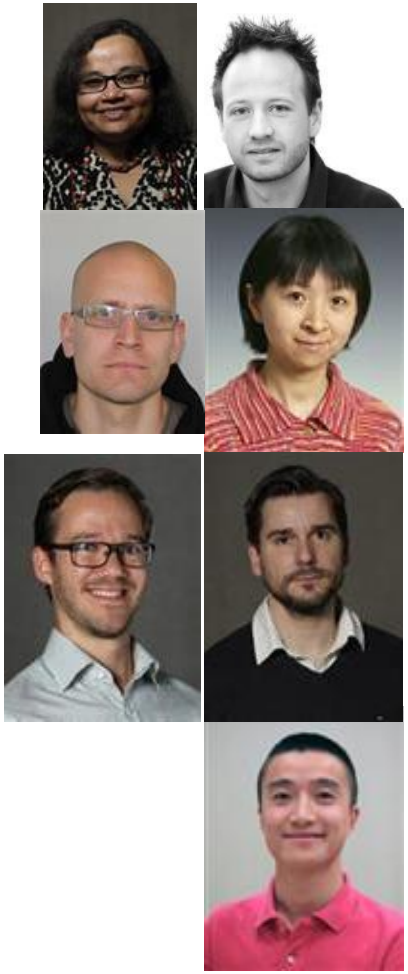
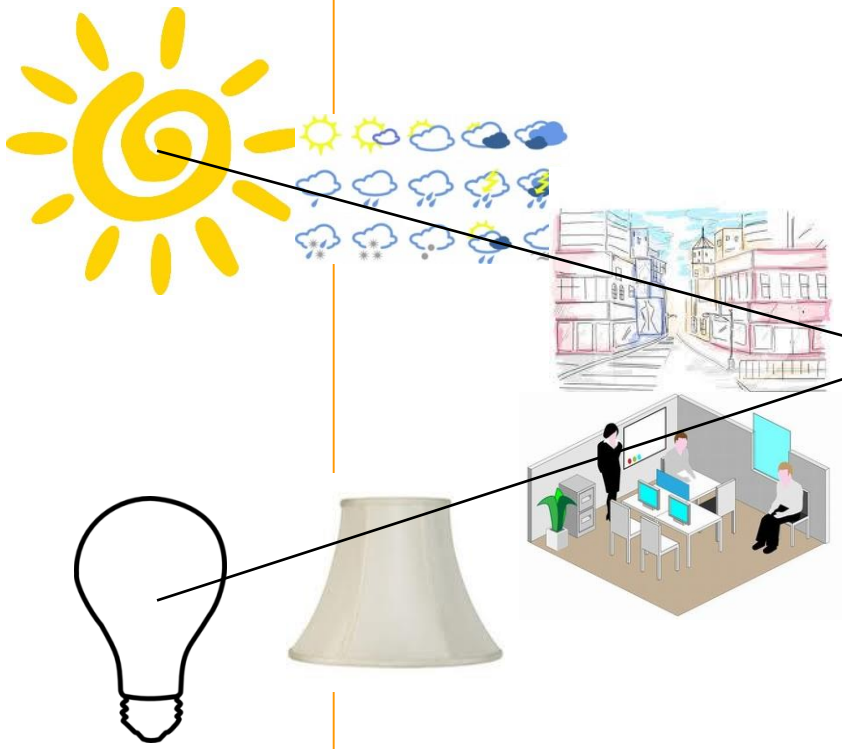
LED Teamet ved DTU Fotonik – RISØ Campus

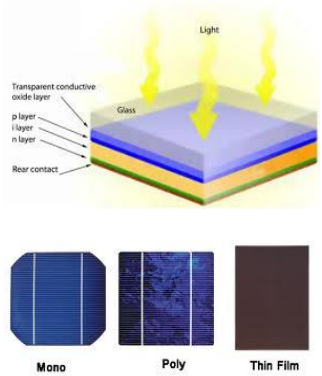


Vores solcelleforskning

Source(s) | Optisk modellering | Optiske systemer | PV systemer

Radiation



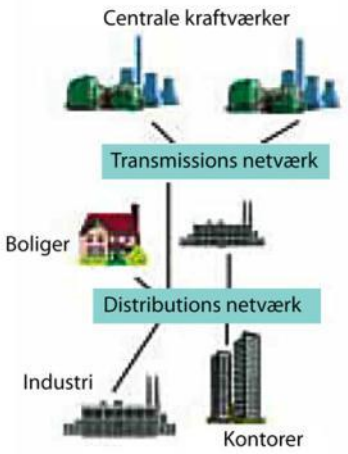


- Elektronik
- Lager
- Køling

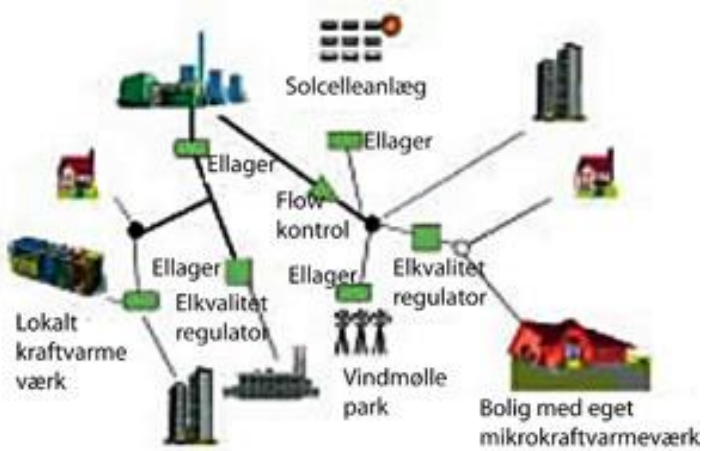
Energioptimering

Elsystemet

Nutidens elsystem

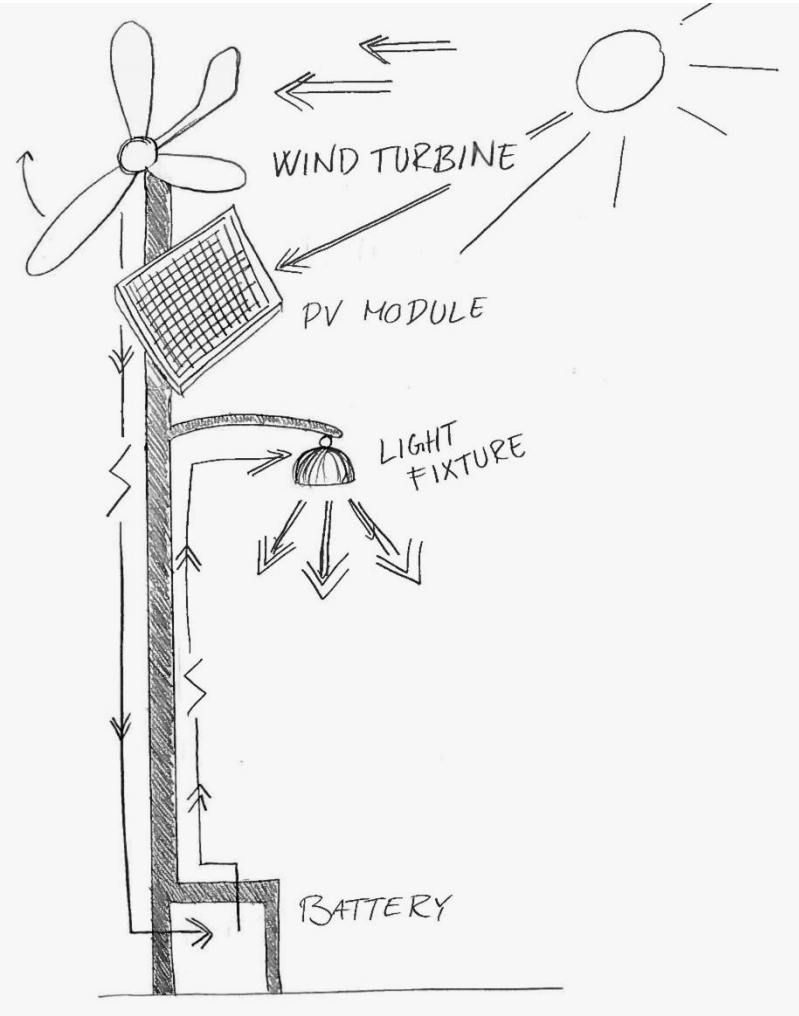


Fremtidens distribuerede elsystem



Energiproduktionen rykker tættere på brugerne

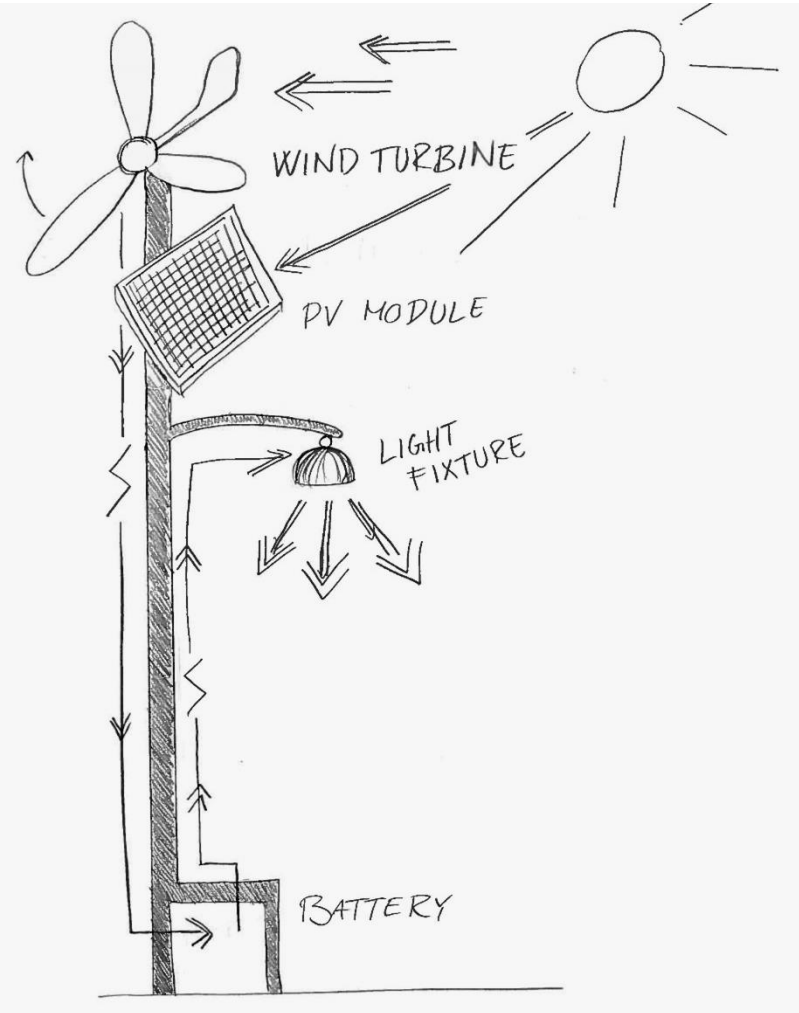
Hvad er et hybridsystem?

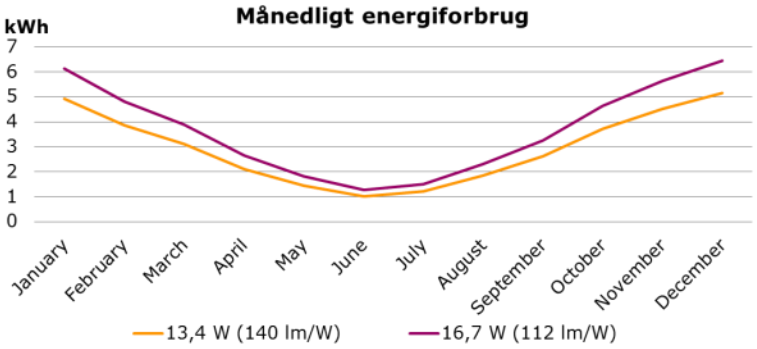


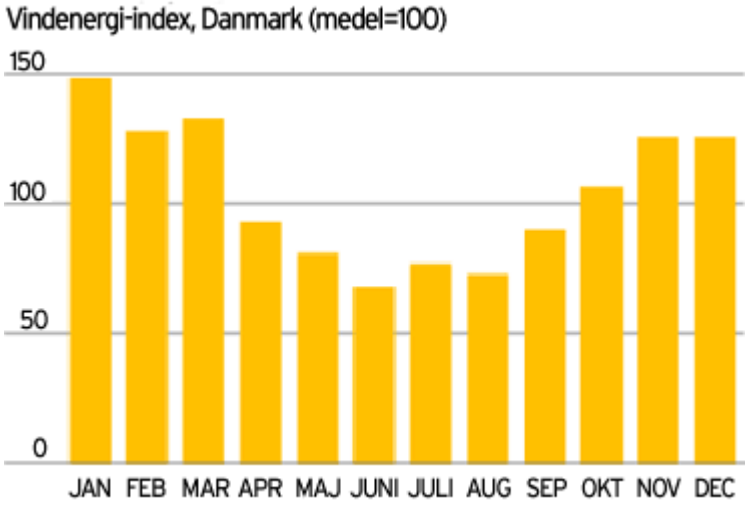
Vision

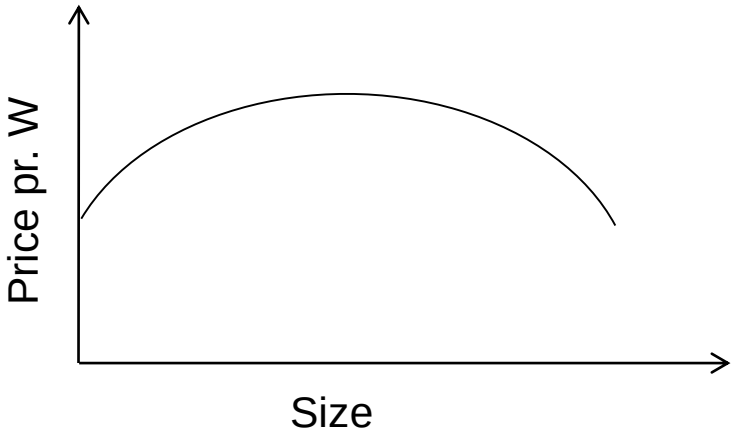
1. Can a hybrid system be developed full filling the needs of the Danish Municipalities?
2. Is there a business model?

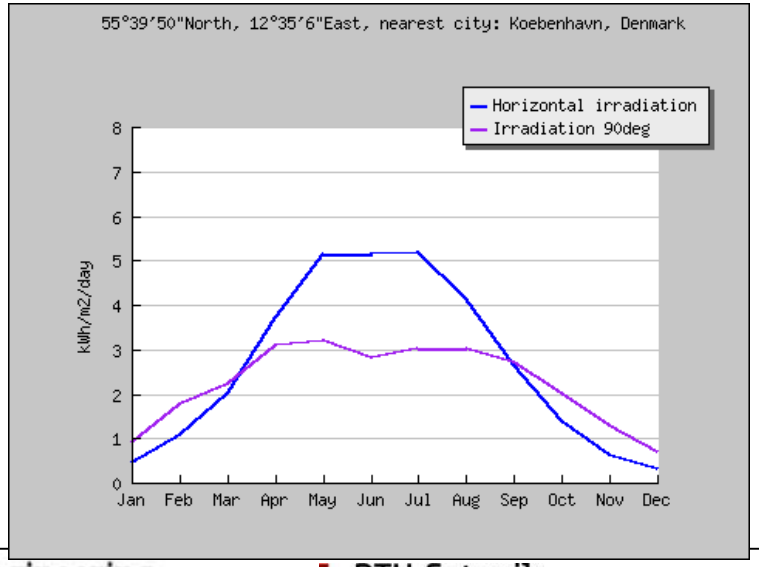
- Stand alone solution
  - Installation, pole, luminaire = free
  - No cabling
  - Free energy
  - Wind turbine, solar panel, battery




Månedligt energiforbrug
kWh
7
6
5
4
3
2
1
0
January
February
March
April
May
June
July
August
September
October
November
December
13,4 W (140 lm/W)
16,7 W (112 lm/W)


Vindenergi-index, Danmark (medel=100)
150
100
50
0
JAN FEB MAR APR MAJ JUNI JULI AUG SEP OKT NOV DEC


Price pr. W
Size


55°39'50"North, 12°35'6"East, nearest city: Koebenhavn, Denmark
Horizontal irradiation
Irradiation 90deg
kWh/m2/day
8
7
6
5
4
3
2
1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

6. november 2013

Society driven innovation

Internationally leading research

- **DTU Wind Energy**
  Department of Wind Energy
- **DTU Electrical Engineering**
  Department of Electrical Engineering
- **DTU Fotonik**
  Department of Photonics Engineering

Producers

PHILIPS sense and simplicity

PRIESS

Sweet spot

Users

GATE 21 SUSTAINABLE FUTURE FORUM

KØBENHAVNS KOMMUNE

Albertslund Kommune

Egedal Kommune

Specialists

HENNINGLARSEN ARCHITECTS

faktor 3

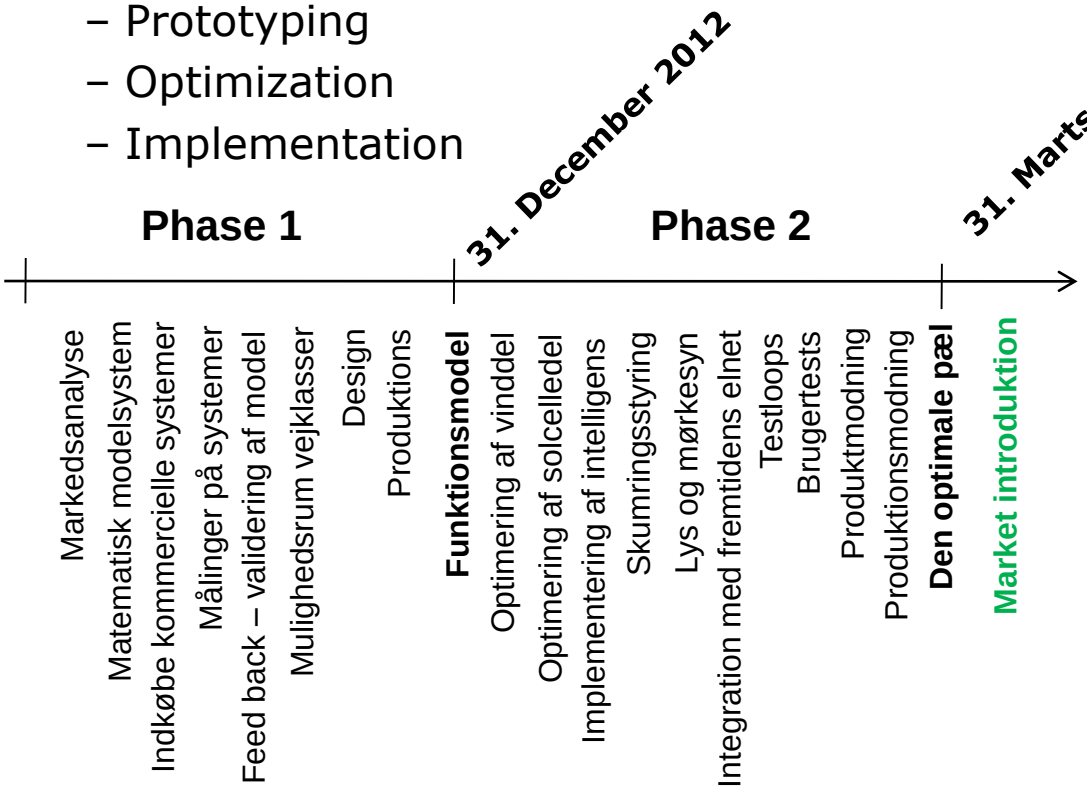
DONG energy

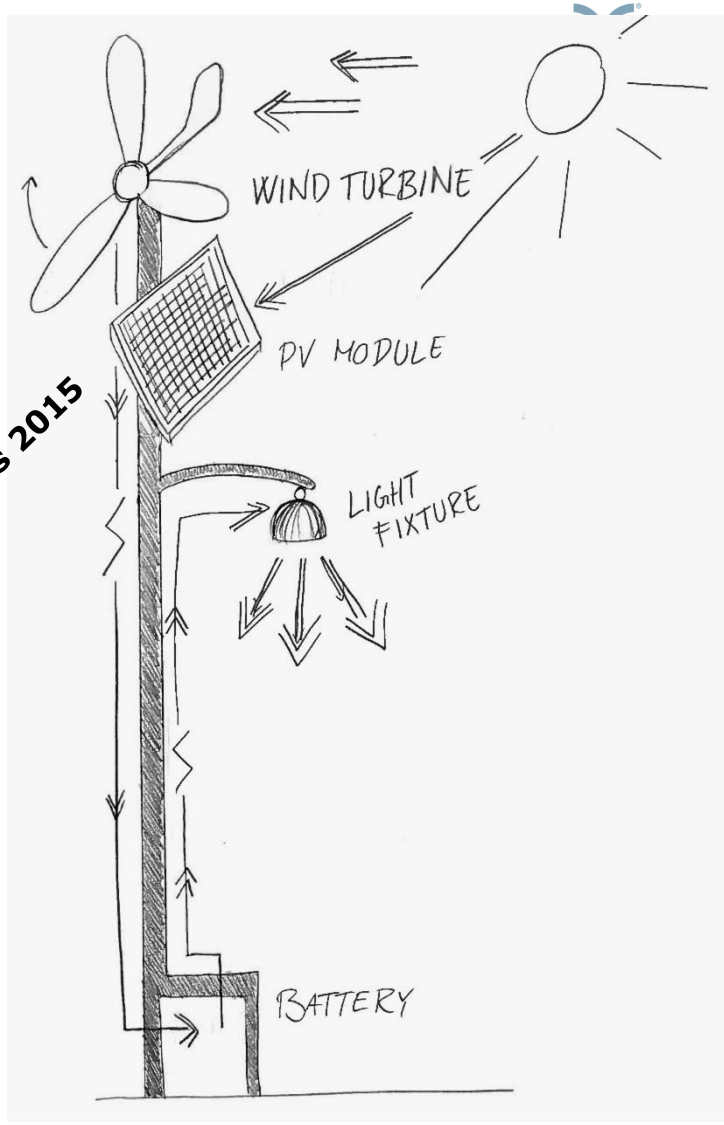
Project contents

- ✓ Screening of commercial hybrid systems
- ✓ Purchase and installation of the 5 best commercial systems on RISØ
- ✓ Characterization of energy systems
- ✓ Logging on the energy systems
- ✓ Mathematical model
- ✓ Feedback from commercial systems
  - ✓ Validation of mathematical model
  - ✓ Analysis of energy systems and components in commercial lamps
- ✓ Mapping the potential energy as a function of street lighting class
- ✓ Select street lighting class for the design process
- ✓ Lab model
- ✓ Mock up
- ✓ Renderings
- ✓ Reporting

Phase 1 of larger project

- Phase 1
  - Analyzing and modelling
- Phase 2
  - Prototyping
  - Optimization
  - Implementation





Screening of hybrid system market

- 29 hybrid systems identified (January 1st 2012)
- Official document
  - Director Center for Traffic CPH
  - Price
  - Delivery time
  - Data sheets
- Suppliers
  - Primarily in China (some with EU sales office)
  - 2 USA
  - 2 Canada
  - 2 Korea
  - 1 France

Primarily wind turbine suppliers

Copenhagen January 24th 2012

To suppliers of hybrid street lighting solutions

The capital of Denmark, Copenhagen Municipality is facing a major challenge with its ambition of being CO2 neutral by 2025. Large renovations of street lighting systems will go on in the next few years and this field is therefore on target for special attention, due to the opportunity for realizing large energy saving potentials that new technologies offer, such as LED, solar cells and perhaps small wind turbines when integrated into street lighting.

Denmark has due to its location to the north special challenges due to long and dark winters with very low potential for solar cell energy creation and a high need for lighting due to long dark periods. These periods are though very windy and wind turbine solution seems obvious. The summer period are almost without wind but very sunny due to the very long days and short night time and a solar panel solution is perfect for this period. So to fit the weather conditions in Denmark a CO2 neutral solution for the urban environment seems to be a hybrid solution based on LED, solar panels and wind power technologies.

Since the energy saving need is the same for all the municipalities in Denmark which shall be independent of fossil fuels by 2050, Copenhagen Municipality has teamed up with the Technical University of Denmark to find the perfect hybrid street lighting solutions on the market suitable for fulfilling the lighting requirements in Denmark.

The Technical University of Denmark will in first half of 2012 be obtaining and testing relevant hybrid street lighting solutions under Danish conditions. In order to prepare a recommendation for the Danish municipalities, we are requesting technical specifications, data and prices from suppliers.

We hope that you can help.

Sincerely

Niels Tørslev
Center Manager

CITY OF COPENHAGEN
Technical and Environmental Administration
Centre for Traffic

Risø DTU
National Laboratory for Sustainable Energy

DTU Fotonik
Department of Photonics Engineering

	Windela	Urban Green Energy		Solavero	JL Carbon Free Energy		Remote Hybrid systems	Cygnus		United Electricity	AnHui Hummer Dynamo		Hefei Liuming New Energy Tehnology		Everlast Lighting	Suneco	Nheolis	Linkone Power	MacroWind	Nanjing Supermann Industrial		Jiangsu KingSun Ningbo United Lighting		Shenzhen TIMAR Windenergy etc.		Link Light	Green Power Generator		Windrex	
Response to mail	·	·	·					·	·	·	·			·			·		·	·	·						·	·	·
PV power	·	·	·	·	·	·		·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
PV technology								·				·	·	·	·		·			·	·	·	·		·				
PV size	·	·															·												
Placement	·																												
PV characteristics		·	·												·		·												
Wind power	·	·	·	·	·	·		·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Wind technology	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Rotor size	·	·	·	·	·	·		·	·						·		·			·				·			·		
Rated wind speed	·	·	·		·	·		·	·						·		·			·				·			·		
Power curve available	·	·	·														·			·							·		
Cut in wind speed	·	·	·	·	·	·		·	·						·		·		·	·							·	·	·
Cut out wind speed	·																			·				·				·	·
Start up wind speed					·	·		·	·						·		·			·				·				·	·
Survival wind speed	·	·	·		·	·		·	·								·			·				·					
Blade material		·	·		·	·		·	·						·														
Noise level		·	·	·	·	·																		·					
Light power	·	·	·	·	·	·				·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·		·		
Light technology	·	·	·	·	·	·				·	·	·	·	·		·	·	·	·	·	·	·	·	·	·		·		
Light output		·	·									·	·	·	·		·	·	·					·					
Light efficiency	·											·	·	·															
Light horizontal plane	·																·	·											
Color temperature	·														·		·												
Color rendering index	·														·		·												
Covered area	·			·											·		·	·	·								·		
Battery capacity	·	·	·	·	·	·				·	·	·	·	·	·	·	·	·	·	·	·	·		·	·	·	·	·	·	·
Battery technology	·	·	·		·						·			·	·	·		·		·				·				·		
Number of batteries	·			·									·				·	·	·	·	·							·		
# of days without wind+sun	·	·								·		·	·	·			·	·	·	·	·						·		·	·
Lights # of hours	·									·		·	·	·			·	·	·		·						·		·	·
Pole height	·	·	·	·	·					·	·	·	·	·	·		·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cost	·	·					·	·	·	·	·			·		·	·	·		·	·			·				·		
Voltage level	·	·	·	·		·					·	·	·	·	·	·	·	·	·	·	·		·	·	·			·		

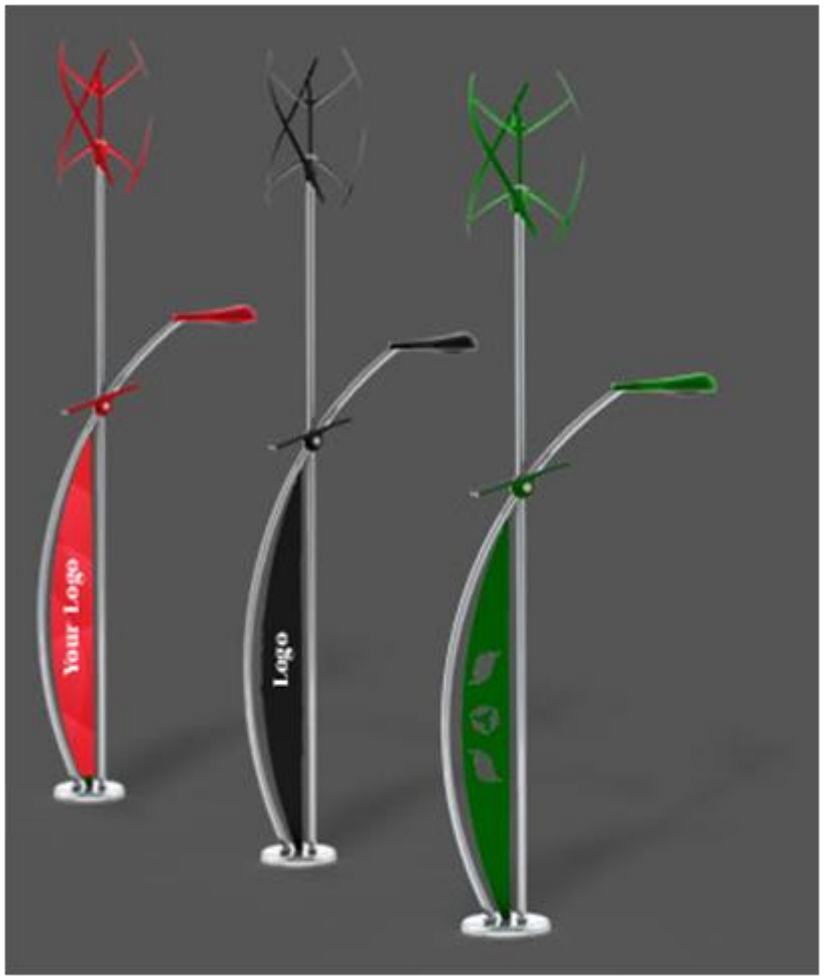
4 commercial systems was chosen

- Delivery time
- Rotor types
- Specifications
- Different distributors
- Different parts of the world

China Green Power

United Electricity

Urban Green Energy



Nheolis


11:15 22/MAY/2012


3
11:11 22/MAY/2012


11:18 22/MAY/2012


nheolis
11:03 19/JUN/2012


11:06 19/JUN/2012


DTU


3

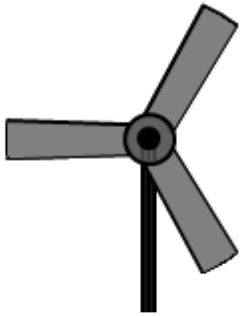
6. november 2013

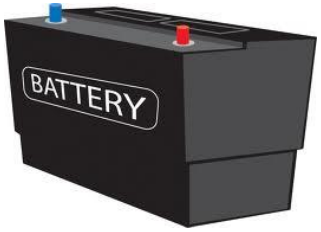
Test platform for hybrid systems

DTU Wind Energy
Department of Wind Energy

DTU Fotonik
Department of Photonics Engineering

DTU Electrical Engineering
Department of Electrical Engineering

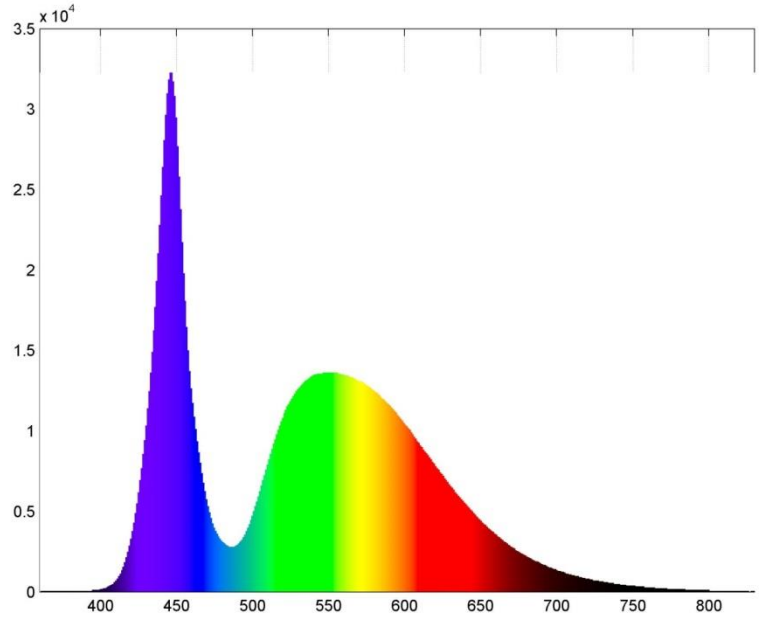




DTU Fotonik
Department of Photonics Engineering

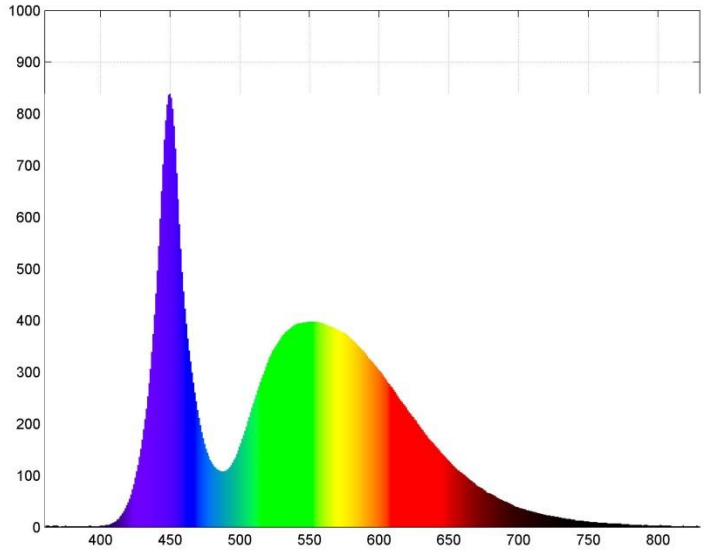
DTU Energy Conversion
Department of Energy Conversion and Storage

Nheolis



Lamp	Effekt forbrug	Color Rendering	Correlated Color Temperature	Duv
Neohybrid	**60 W**	**73.0**	**7202**	**0.0073 (false)**
China Green Energy	61.5 W	74.4	6663	0.0010 (true)
United Electricity		83.2	4693	0.0041 (true)

China Green Power



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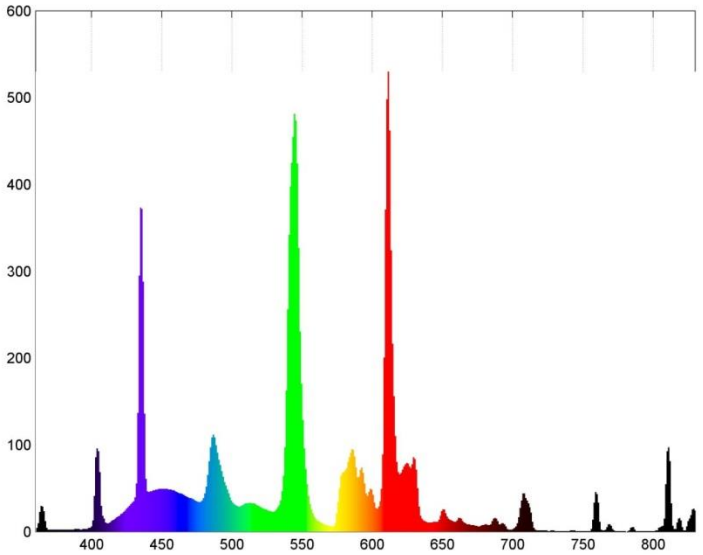
United Electricity



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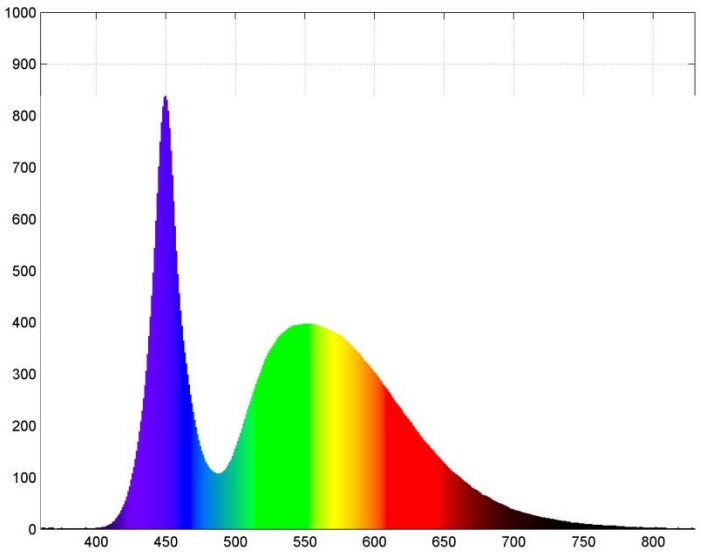
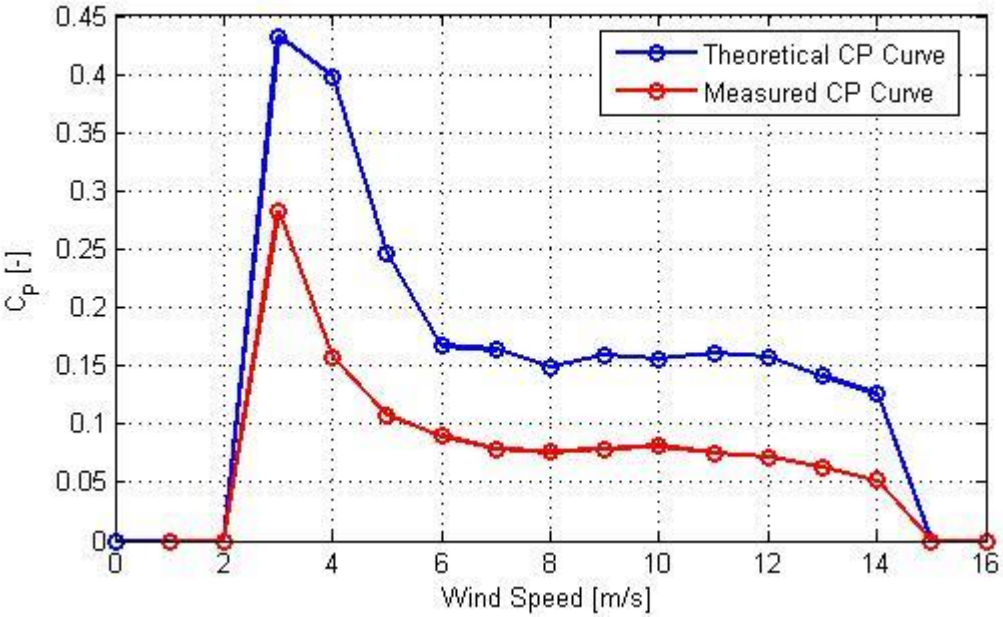
DTU


1000
900
800
700
600
500
400
300
200
100
0
400
450
500
550
600
650
700
750
800

About 6600 K

Wind turbine power curves

- Average wind speed in the urban environment: 1,5 m/s
- Challenges in turbine design and generator design



Wind turbine power curves

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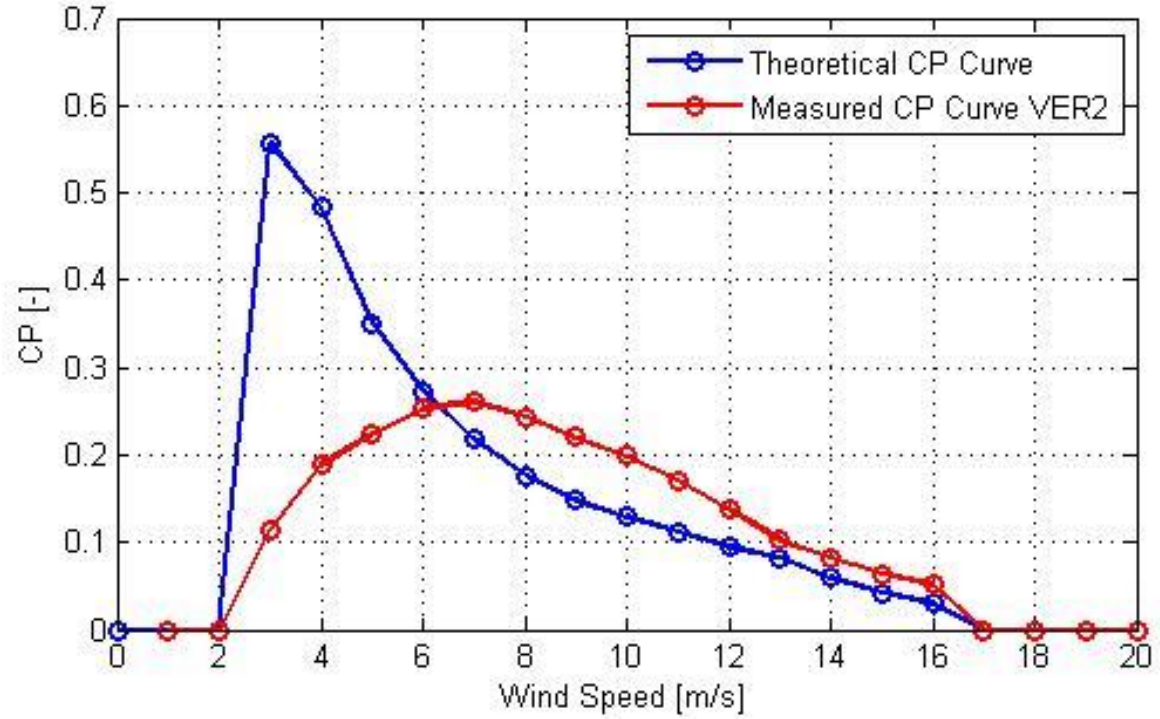
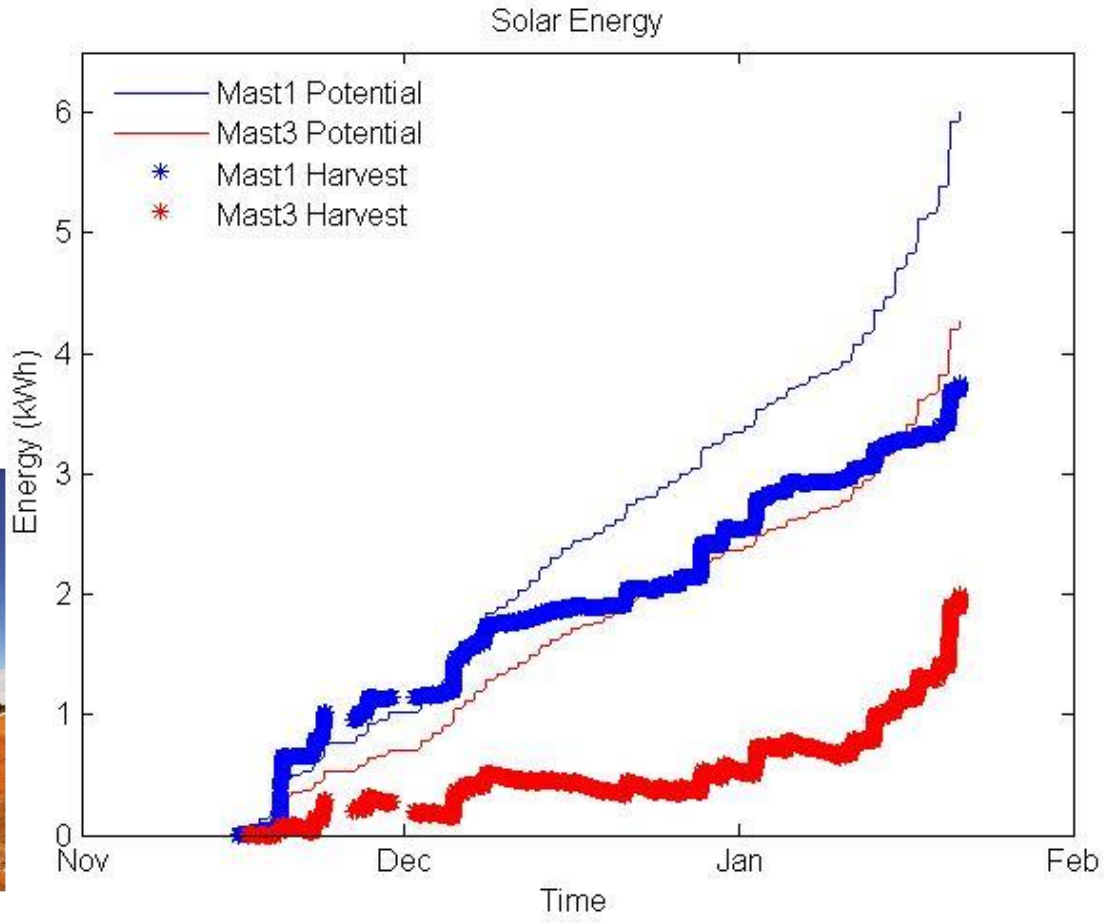


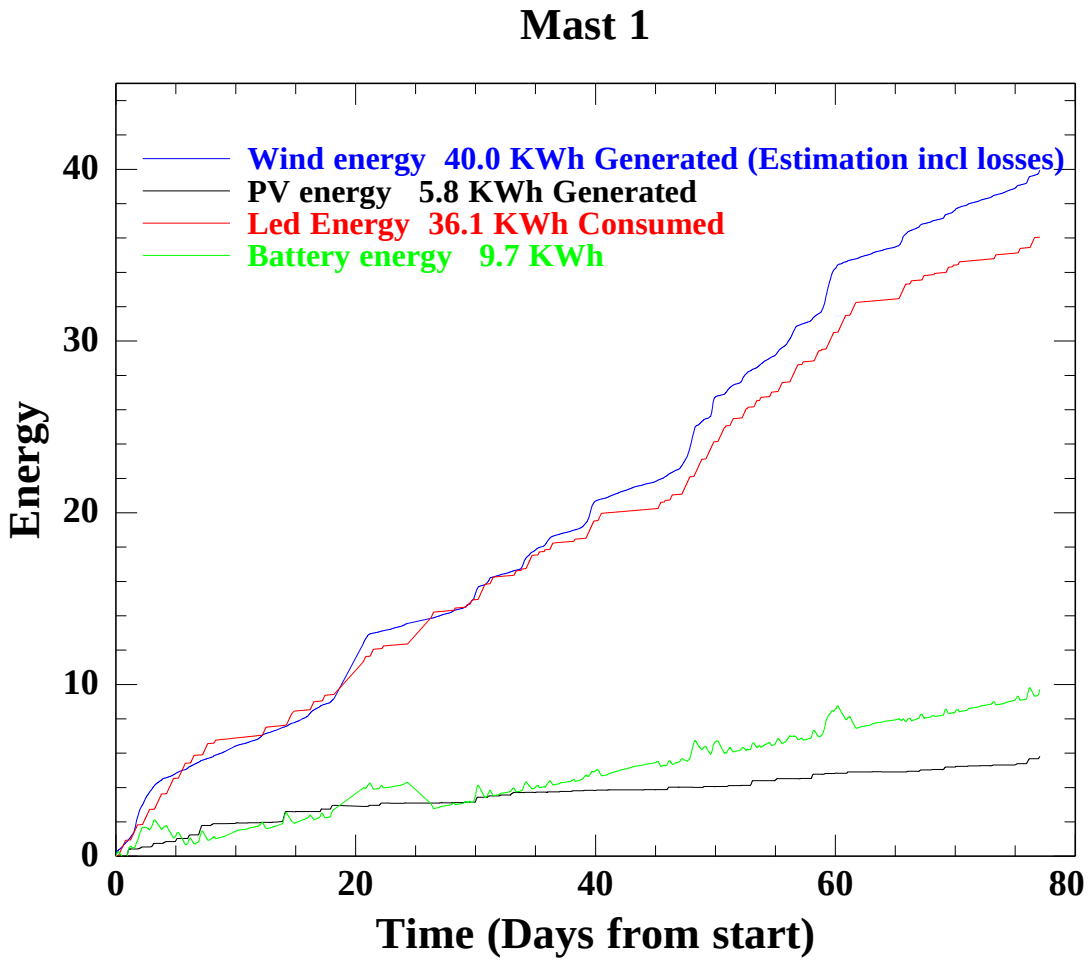
Solar panels



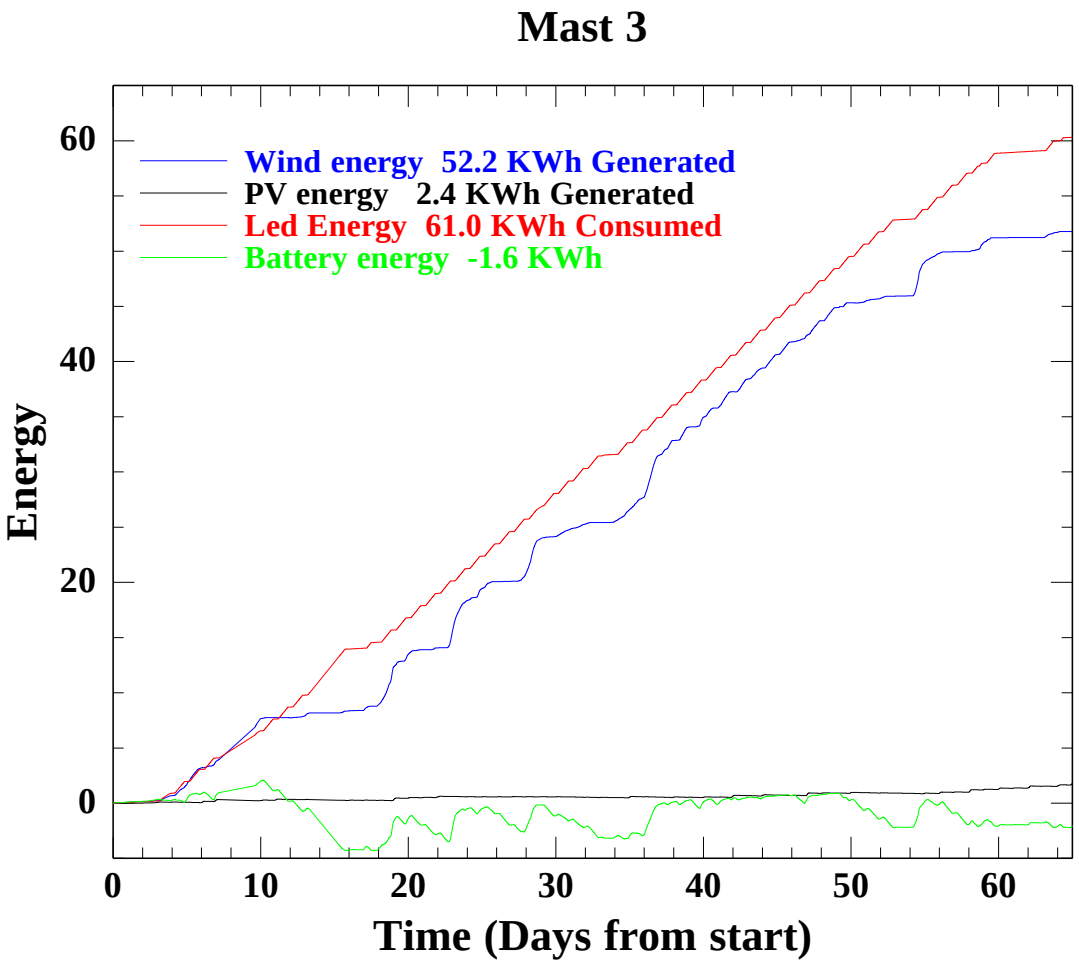
Batteries

- Very cheap lead acid battires
- 1 VRLA battery
- Short life time

Energibalance



Energibalance



Masts – deliveries - mechanics

- Extremely interesting deliveries (mast 1 had it all)
  - Mast 2 (without battery, mast, fittings, wiring - all in Chinese)
  - Mast 3 (lamp did not work - all in Chinese)
  - Mast 4 (without batteries, wires, brackets - all in Chinese)
- Mast 2 - damaged bearing after a week (change)
- Systems corrode violently

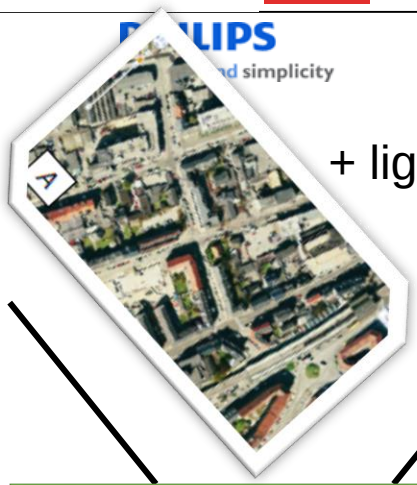
Delkonklusion markedsanalyse

- Umodent marked – primært domineret af kinesiske leverandører
- Virksomheder sælger små vindmøller
- Uoptimerede tekniske løsninger
- Uegnede til danske vejr
- UrbanGreenEnergy virker som en seriøs leverandør

State of the art - benchmarking

- Challenges on the delivery side – missing components
- Documentation
- Optimization of the wind turbine unit (generator starting at lower torque, gears, etc.)
- Optimization of solar panels (primarily the electronics – angling)
- Better LED units (CCT = 3500-4000, higher CRI)
- Better batteries
- Optimization of controller unit (intelligence)
- Optimization of mechanical system
  - Weatherability
  - Strength
- Better design!!!

Mathematical model



+ lighting requirement+ GPS coordinates

Solar data

Wind data

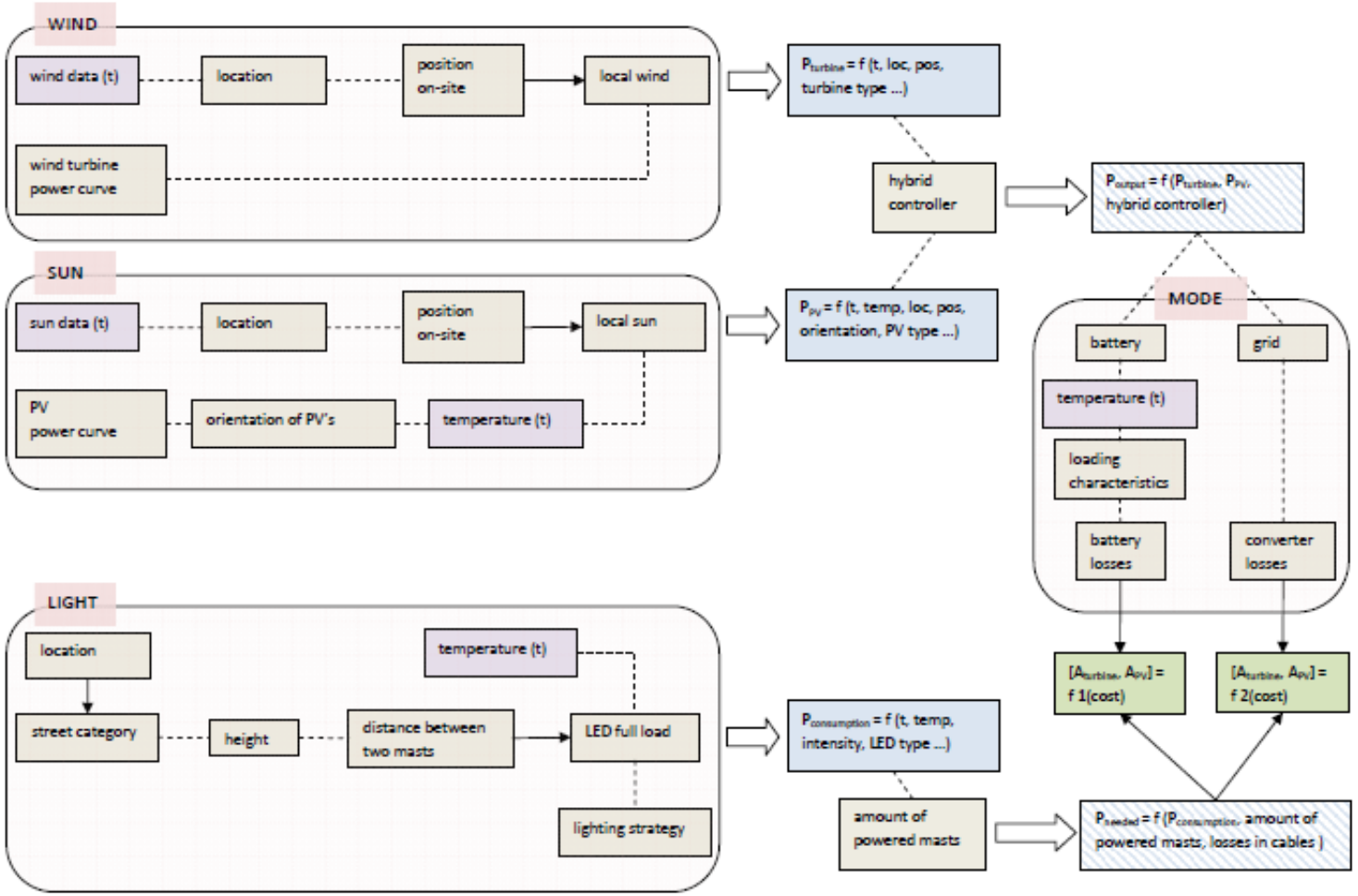
LED energy use

Battery tech.

Mathematical Model

Solar panel area, angle, orientation
Rotor area, placement, rotor type
Battery capacity

Mathematical model



Street classes in Copenhagen

Red: ”Regionale veje”
Dark blue: ”Fordelingsgader”
Light blue: ”Bydelsgader”
Orange: ”Strøggader”
Dark gray: ”Lokalgader”

E2 veje

Wind energy – street classes

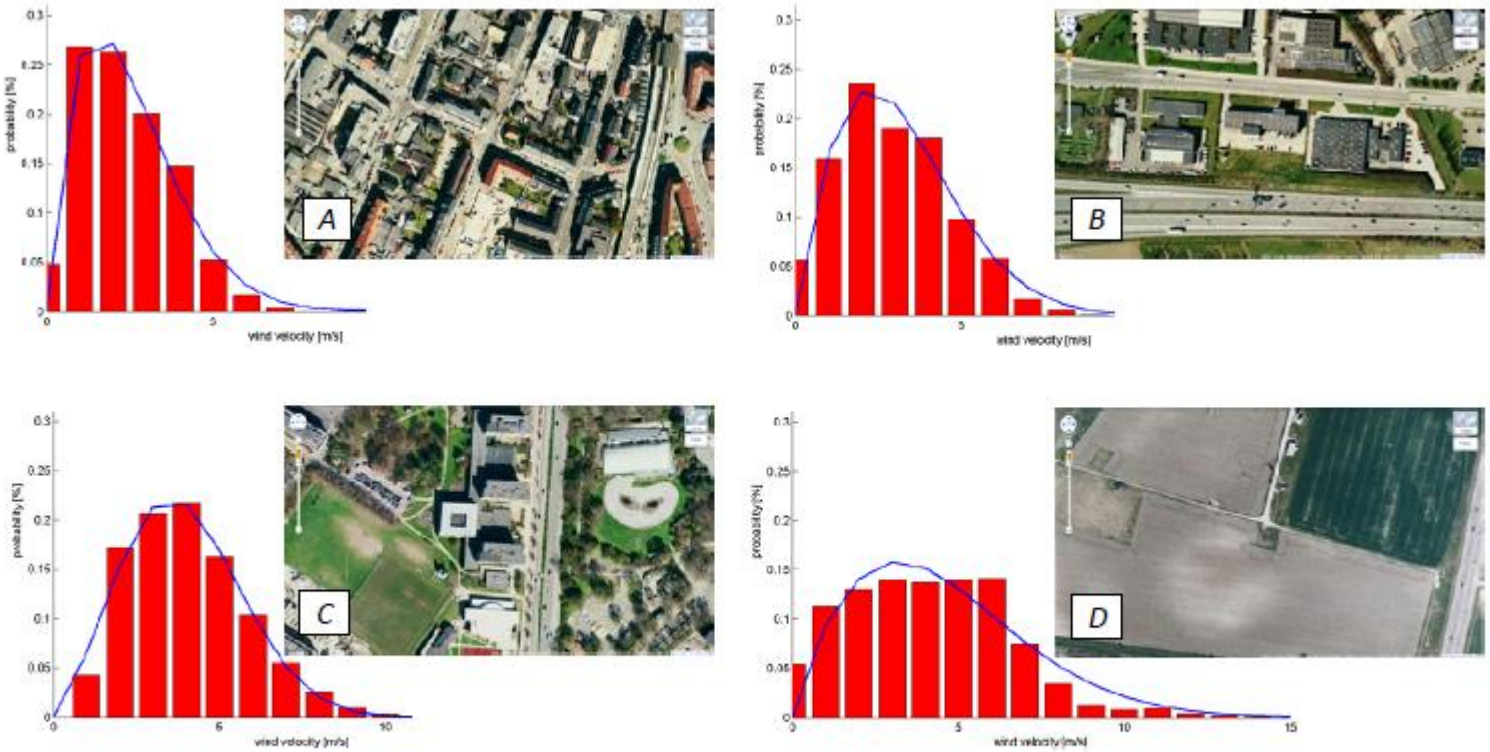


Fig. 106: Weibull distributions for different sites and satellite pictures of the sites

Wind energy – street classes

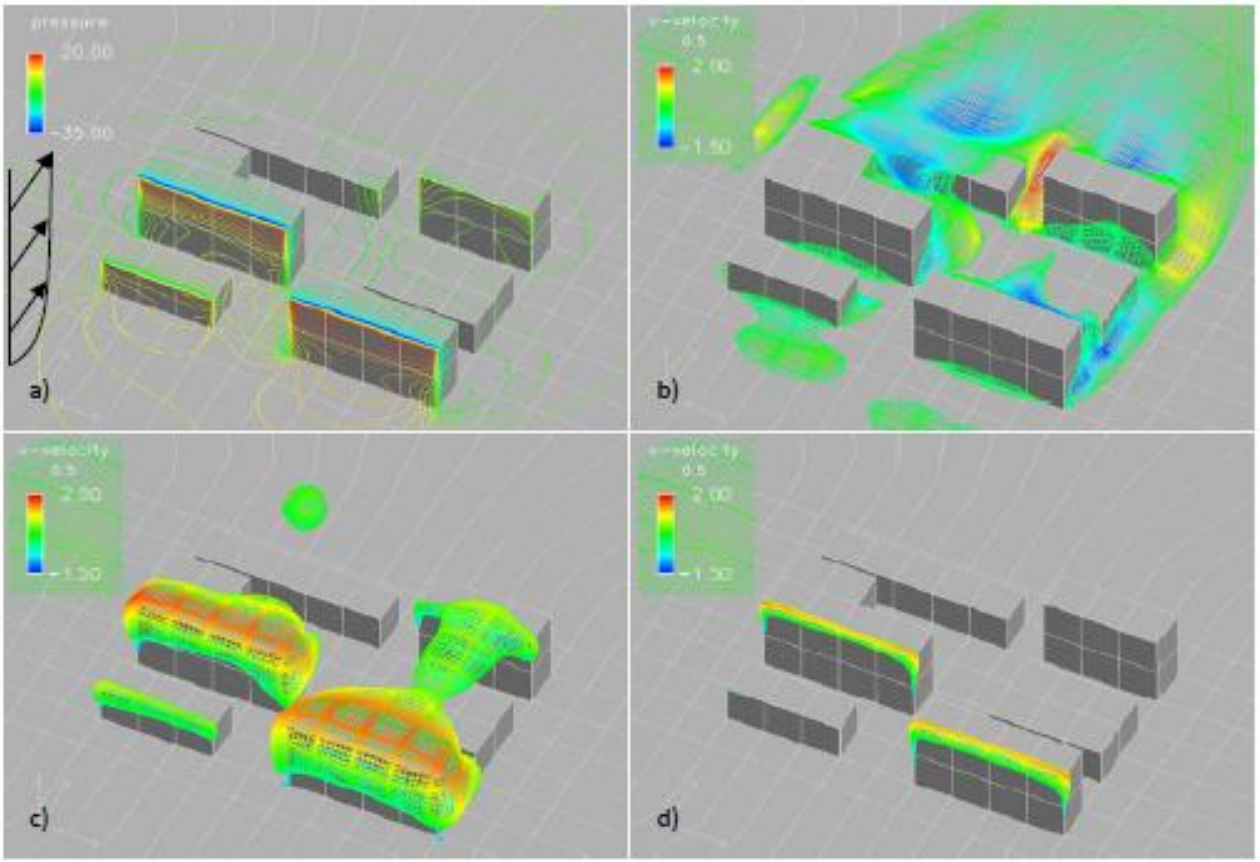
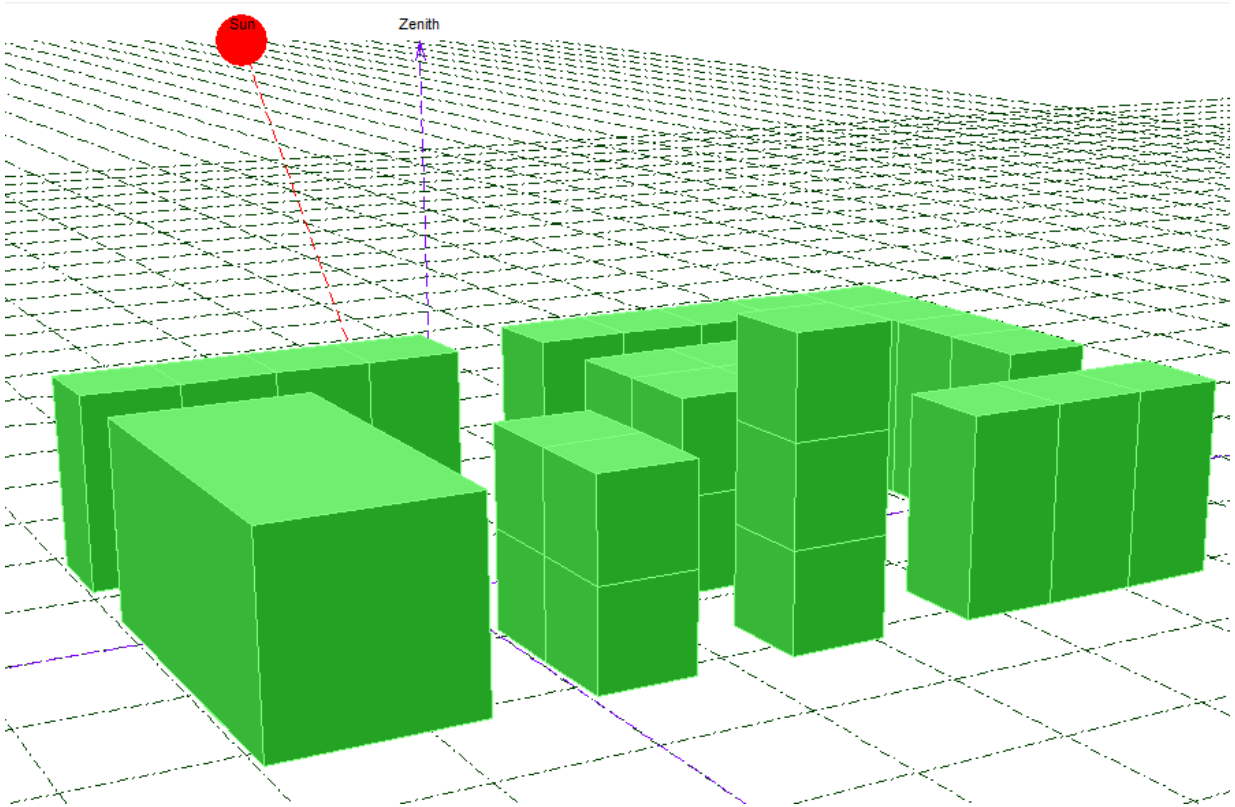
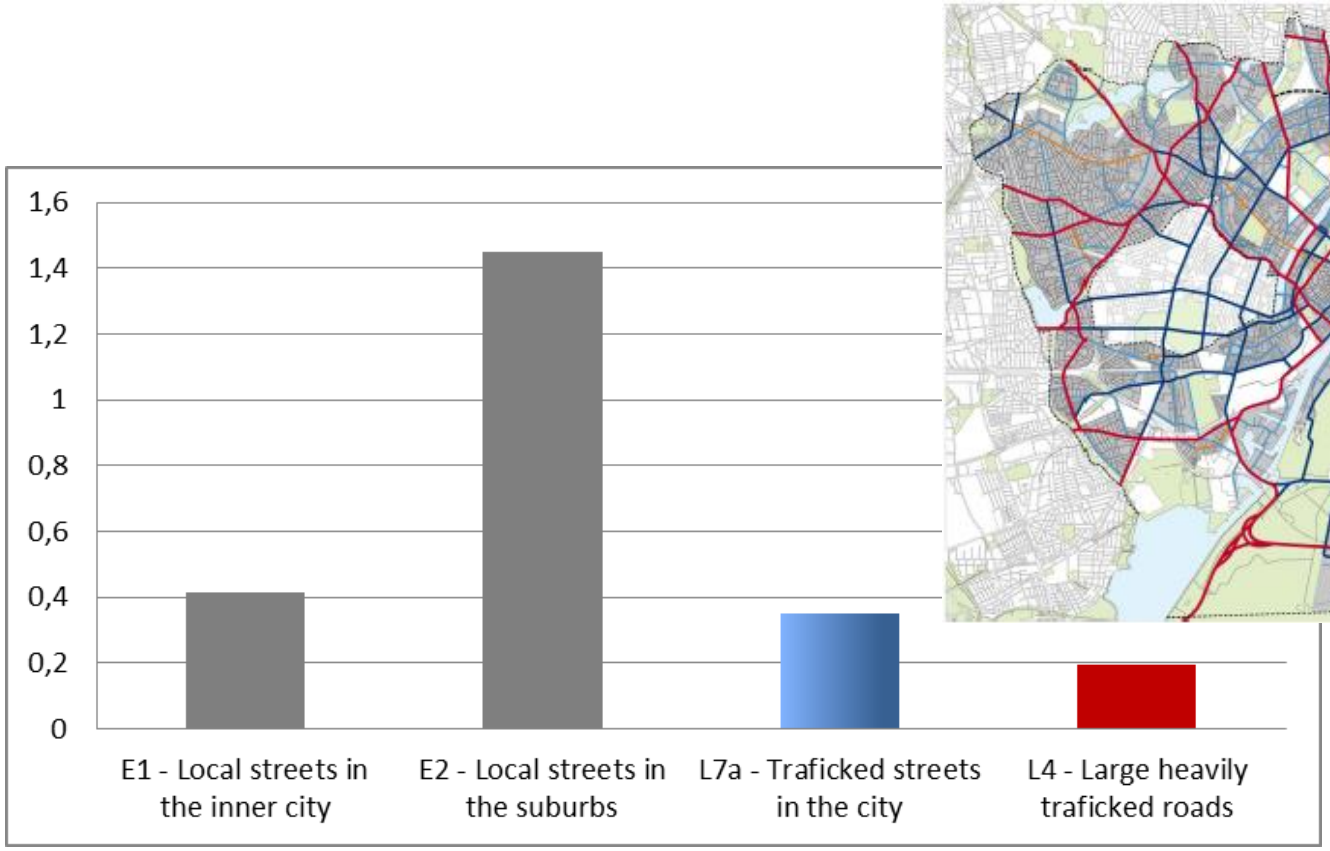


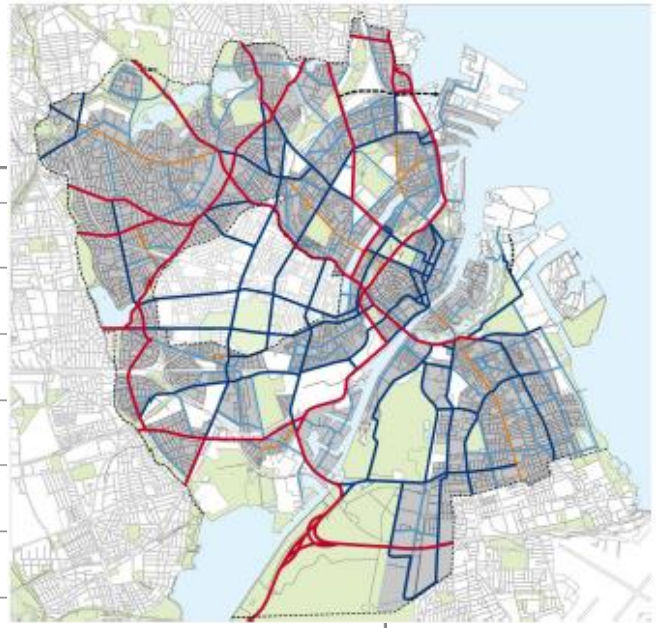
Fig. 33: *CASE4*: a) static pressure distribution; b)-d) *tke* iso-surfaces (*tke*=0.5; 3; 6m^2/s^2) with velocity component *v* distribution

Solar energy- street classes



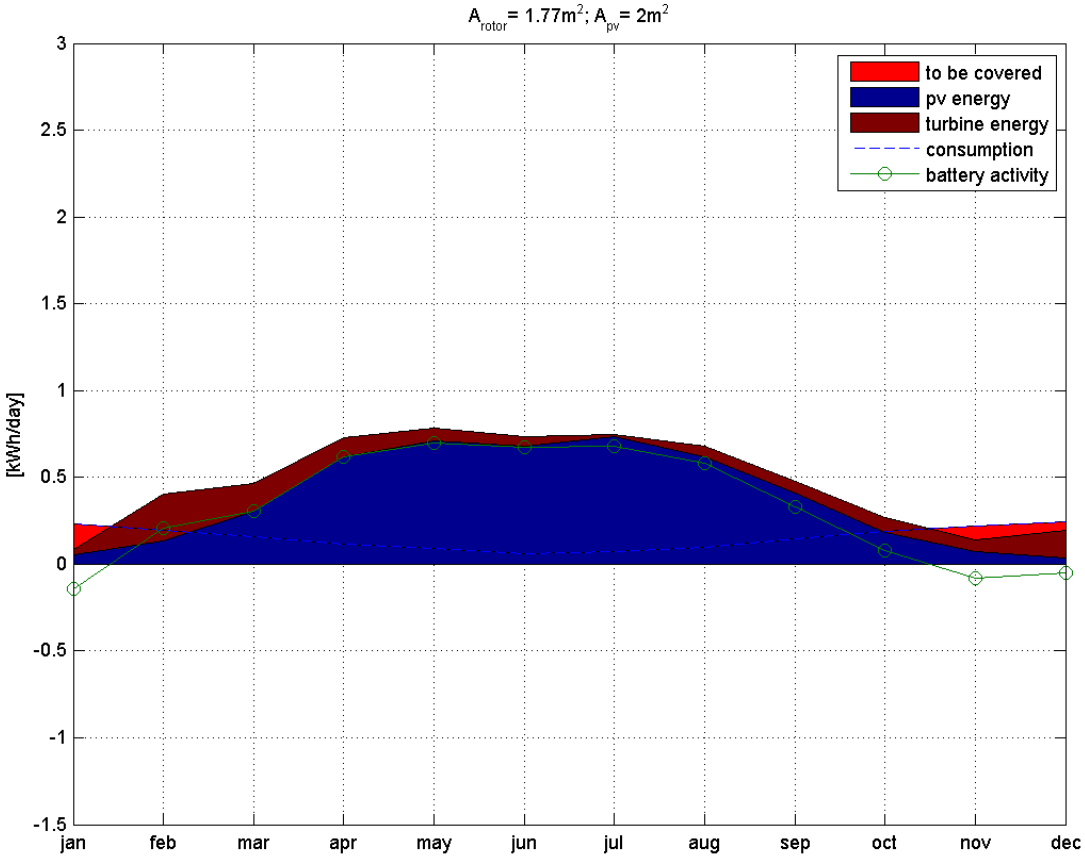
Potential for hybrid street lighting



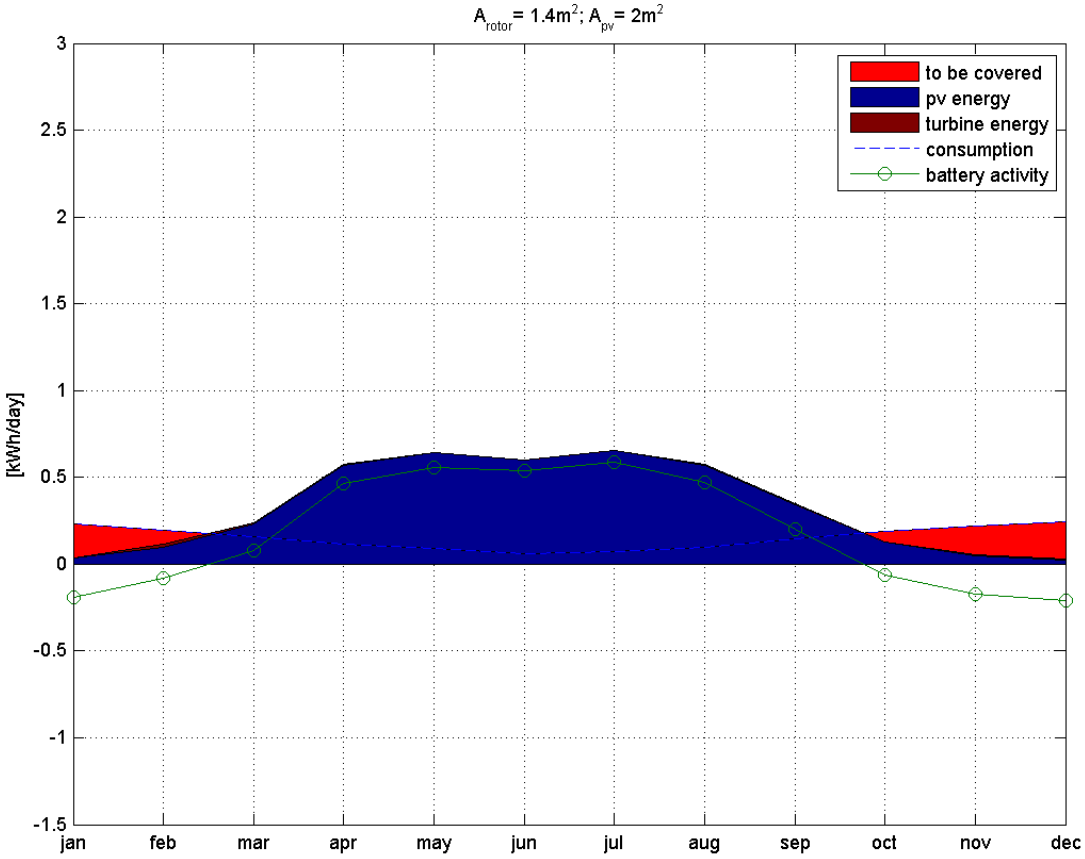


6. november 2013

Energibalance - NHEOLIS

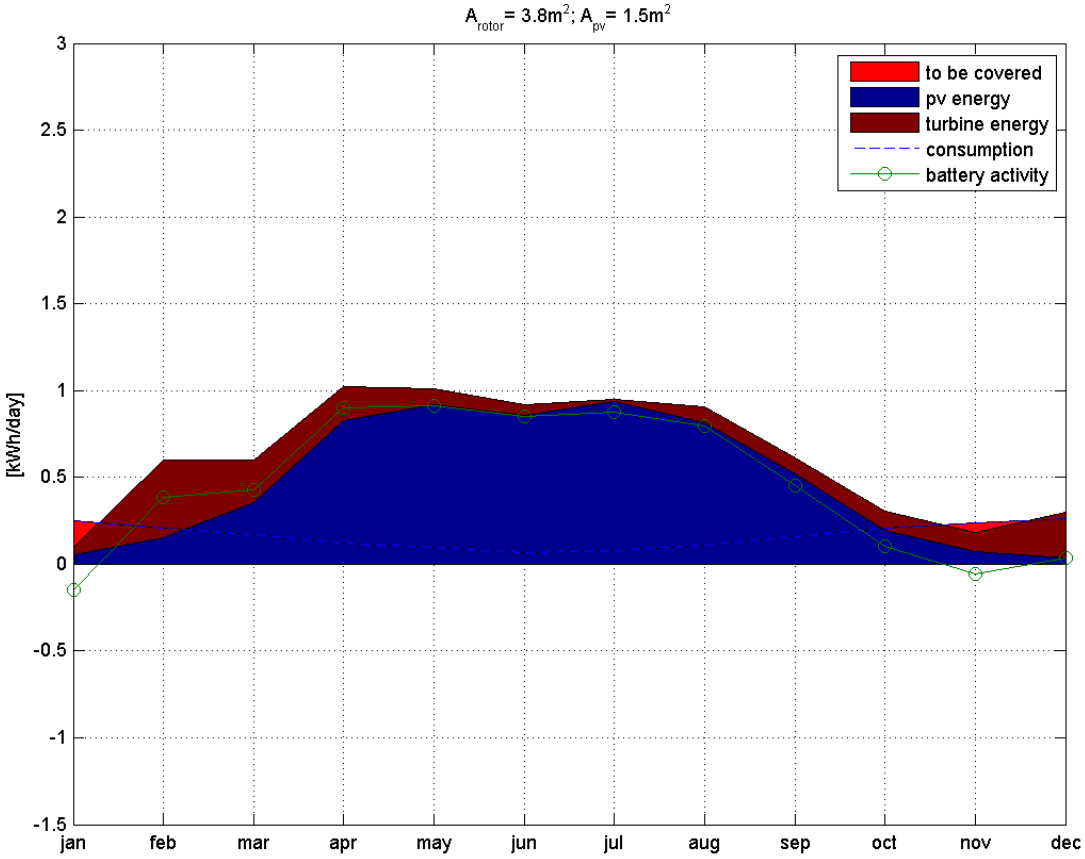


Energibalance - ChinaGreenEnergy



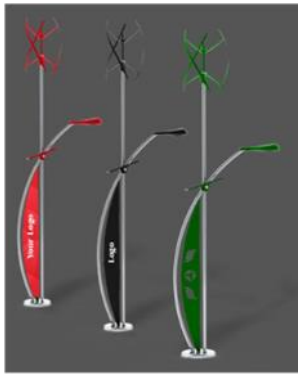
6. november 2013

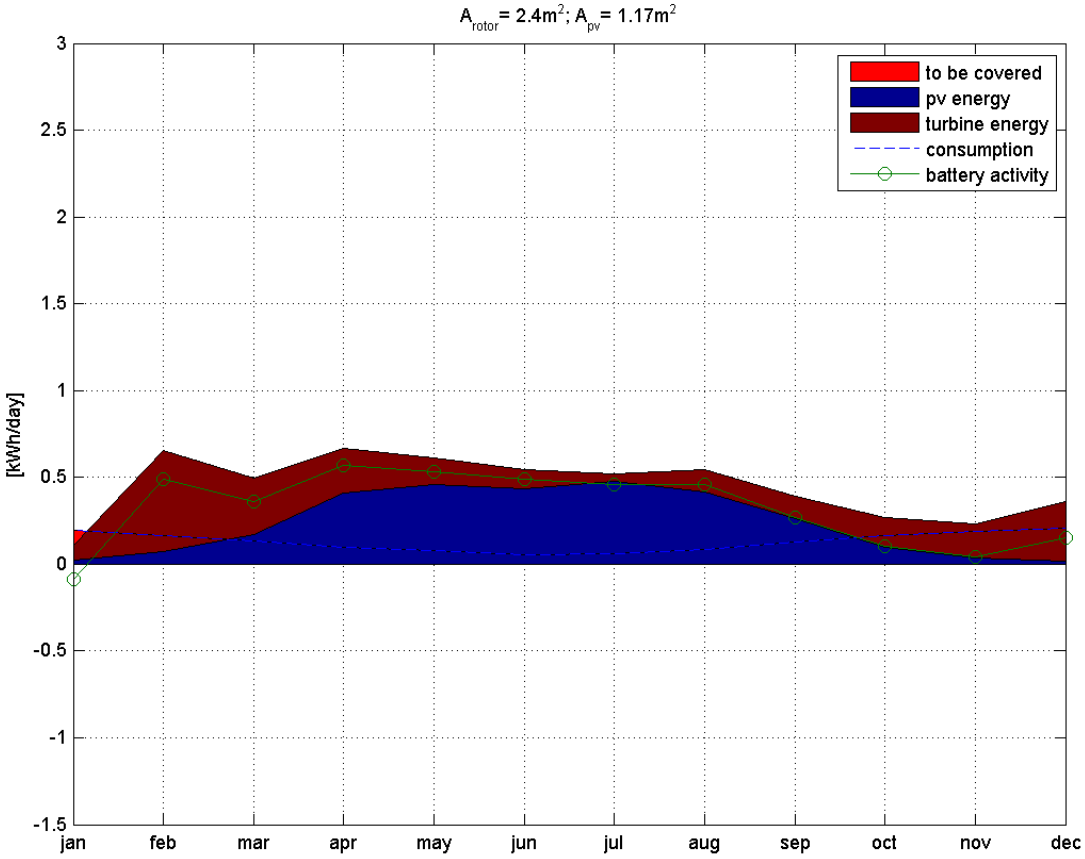
Energibalance – United Electricity



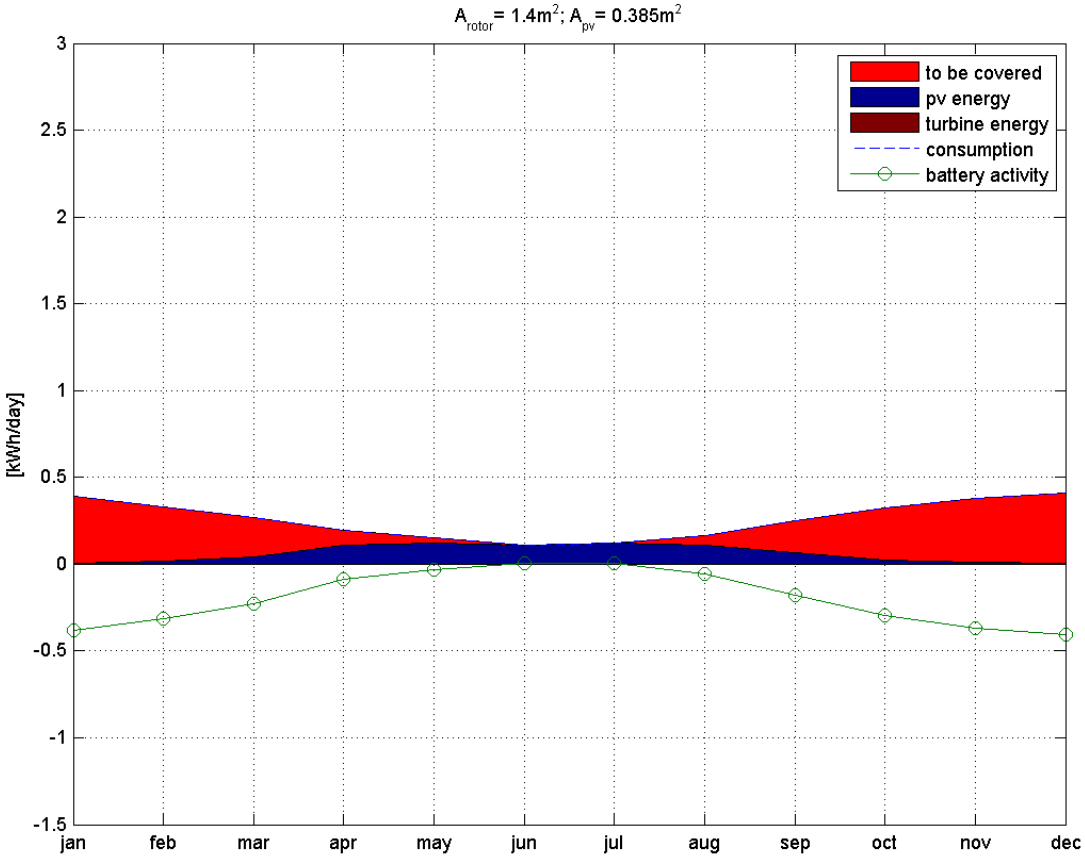
6. november 2013

Energibalance - UrbanGreenEnergy





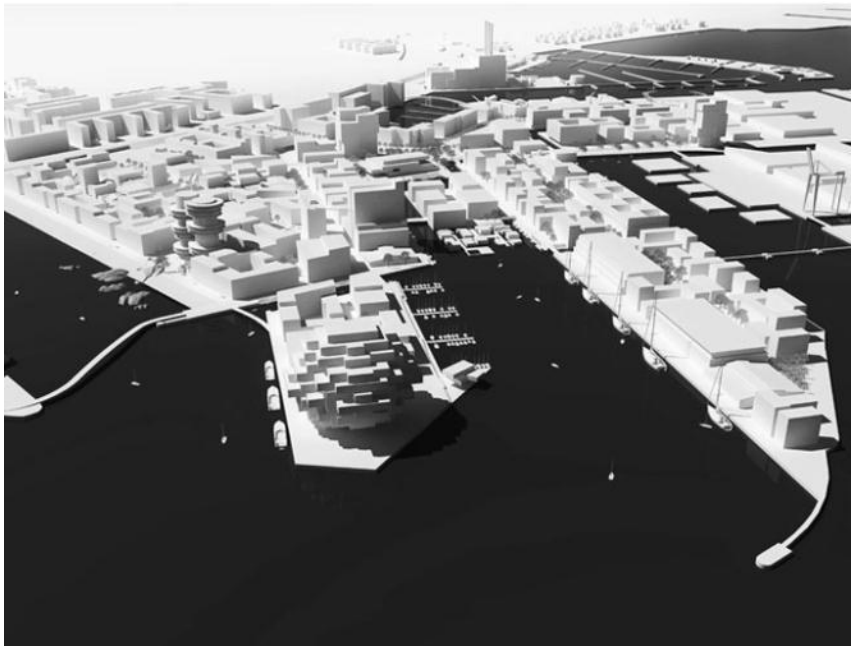
Energibalance Windella



Delkonklusion matematisk modelværktøj

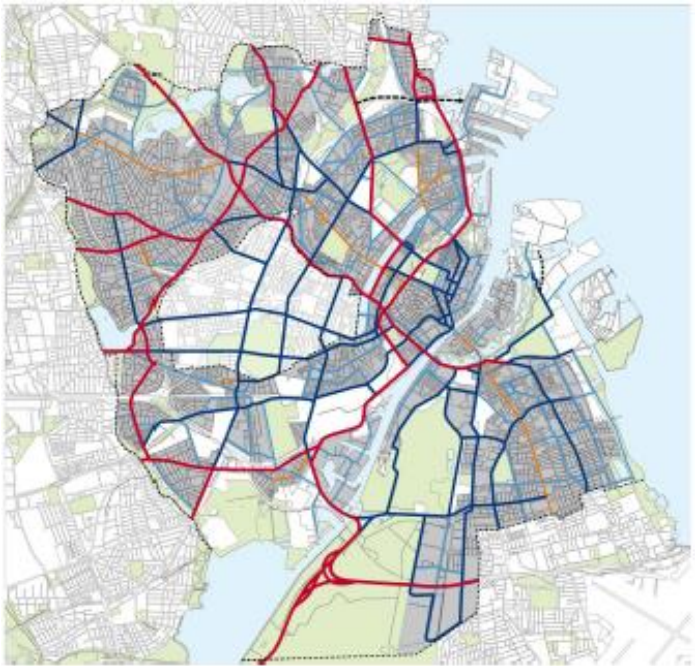
- Stærkt dimensioneringsværktøj/simuleringsværktøj tilvejebragt
- Designprocessen af eget hybridsystem
- Valideres for nuværende med data fra kommercielle systemer
- Gennemsnitsbetragtninger

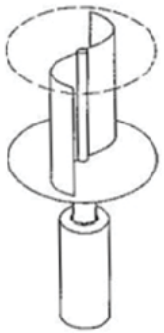
- Udbygning - punktbetragtninger
  - Google Grabber
  - Interface med arkitektsoftware
  - API



Design frame

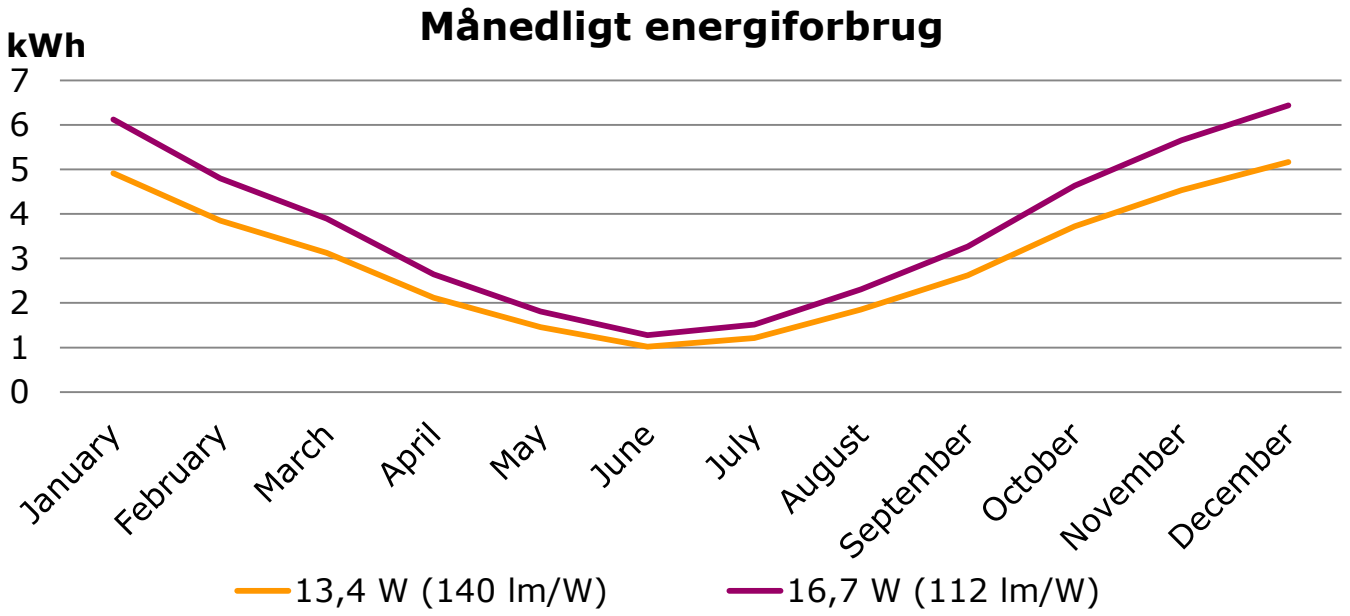
- E2 roads
- Lighting
  - Max 350 Wh/day
  - Illuminated area 30x13 m
  - 80% light falls on the street
  - 85 lumens/watt (3000 K)
  - 2 x 32 LED units Philips
  - Driver Philips
- Wind
  - Savonius
  - 2,3 m^2
- Generator
  - Dia 30 cm, height 15 cm
- Solar panels
  - 150 Wp



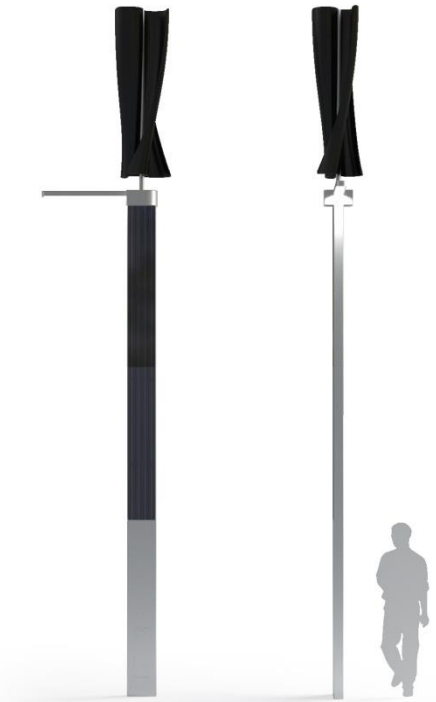

Savonius

E2 - Lokalvej

- 2,5 lux (hemisferisk illuminans) = 1900 lm
- Farvetemperatur på 3000 K
- Ra-værdi > 80



CopenHybrid vs internationalt state of the art

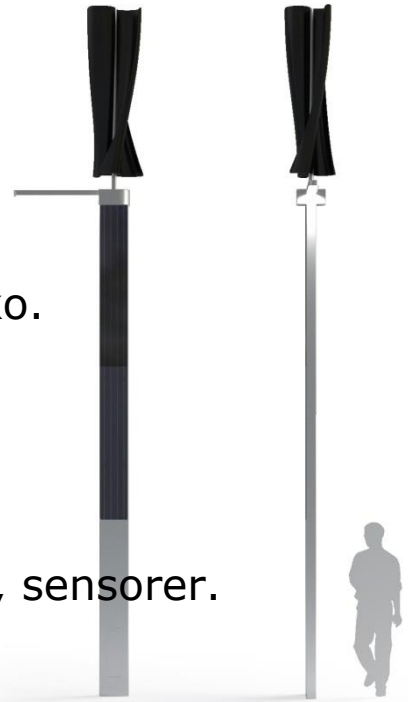


Challenges in phase 2

- Wind energy optimization unit (generator starting at low torque, MPPT on electronics, gear)
- Optimization of solar cell unit (primarily electronics)
- Adjusting the LED unit and implementation of intelligent control
- Optimizing battery pack
- Optimizing the electronics
- Optimization of mathematical modeling system for the design of systems
- Optimization of mechanical engineering / design
  - Weatherability
  - Strength
  - Production

Konklusion

- Afdækning af kommercielle systemer
  - Design, Energisystem – forbrug - vejr, Rotordesign, Kvalitet
  - Elektriske system, Generator
- Matematisk modelsystem
  - Vurdere potentialet for kommercielle systemer
  - Designe nye systemer
  - Feed back fra kommercielle systemer
- Mapping af energipotentiale som funktion af vejklasse/øko.
- Designproces/Funktionsmodel
- Kan et hybridsystem fungere i dansk context:
  - Ja, men er worst case i forhold til resten af verden
- Er der en forretningsmodel?
  - Ja, Kabling er ekstremt dyrt. Solceller billige, LED eff, sensorer.
  - Eksportpotentiale stort
- Fase 2 ansøgt ELFORSK/EUDP
  - Generator, energisystem, optimering, produktionsmodning
  - Investorer



Tak til ELFORSK

ELFORSK 343-021 - CO_2 neutralt byrumsarmatur

ELFORSK

Tak for jeres opmærksomhed!